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Procedia Technology 10 (2013) 646 – 653

Procedia Technology

International Conference on Computational Intelligence: Modeling Techniques and Applications (CIMTA) 2013

# Automatic Eye Detection using Fast Corner Detector of North East Indian (NEI) Face Images

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**Abstract**

This paper has focused on automatic detection eye over North-Eastern Indian (NEI) face database, which is recently developed and continually expanding in Biometric Laboratory of Tripura University (A Central University). For this purpose one of the well-known feature detection technique, called Fast Corner detector has been used. Then after image contrast stretching has been applied over the gray scale image to reduce the illumination effect. Finally, Fast Corner detector is applied over this modified image to discard the other detected points over face. To check the efficiency, the automatically detected eye location has been matched with manually detected eye location


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*Keywords:* Fast Corner Detector; Contrast Stretching; Eye Detection; NEI Faces; USAN Shapes

## 1. Introduction

Like one of the most successful applications of image analysis, face recognition has recently received a significant attention, especially during the past few years. To authenticate the user's identity, a face recognition system is more convenient than other authentication systems like user password and others. There are many face recognition related sub problems like: (i) detection of a pattern as a face (in the crowd) and its pose; (ii) detection of

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Selection and peer-review under responsibility of the University of Kalyani, Department of Computer Science & Engineering
doi:10.1016/j.protcy.2013.12.406

facial landmarks and (iii) analysis of facial expressions. The face recognition systems can be broadly classified in two different ways, such as holistic and feature-based approaches.

The holistic method uses the image of the whole face as a raw input to a recognition system, which considers the global properties of face pattern [1, 2]. As holistic approaches represent the global information of faces, these activities require more processing time to accomplish the recognition task. Due to these limitations feature-based approaches have been considered for face recognition over holistic approaches. Some prominent feature parts of human faces are eye, eyebrows, nose, and mouth. Feature extraction methods can be distinguished in three different ways like (i) generic methods; (ii) feature-template based method; and (iii) structural matching based methods. In the generic methods, edges, lines, and curves of the faces are considered. Facial features such as eye, eyebrows are considered in feature-template based method, and for structural matching methods, the geometrical constraints of the features like face outline, eyes, and mouth are determined and those are considered for perceiving and remembering the faces [3]. The eyes are important facial landmarks, both for normalization due to their relatively constant interocular distance, and for post processing due to them anchoring model-based schemes. The prominency of eyes with respect to the other facial features is due to several reasons [4]:

- Eyes are a crucial source of information about the state of human beings. When looking at a picture of a person, people tend to devote the greatest attention to the eyes. The shape, size, and color of the eyes provide cues in recognizing individuals; it has been shown that the upper part of the face plays a more important role for face recognition than its lower part.
- Faces contain two eyes (if not occluded) that have in general a very similar appearance, so they can be searched simultaneously with the same technique. This allows to roughly identifying the scale of the face (the inter-ocular distance is relatively constant from subject to subject) and its in-plane rotation.
- The eye appearance is less variant to certain standard face changes. For instance they are unaffected by the appearance of facial hair (like whiskers or mustaches) and are almost unaltered by small in-depth rotations of the face (though they look closer to each other due to the perspective change), while the nose appearance greatly changes.
- The accurate eye localization permits to identify all the other facial features of interest [5].
- Eyes (the retina) show certain reflection properties when exposed to near infrared (NIR) light. This characteristic is not sufficient for a robust eye localization due to the presence of many false positives in uncontrolled environments, there-fore it is often used in combination to more traditional (visible light) image analysis techniques.

In this paper, we propose an automatic detection of eyes using fast corner detector with image contrast adjustment (stretching). This paper is organized as follows: the related work about automatic eye detection is discussed in section 2. Section 3 includes present method for automatic eye detection and section 4 presents the accuracy on the proposed method and finally in section 5 the conclusion has been drawn.

## 2. Related Work

There are many researchers focusing on tackling the eye detection tasks. Compared with the active IR based approaches [6], the image based passive approaches are widely used for no additional equipment is needed. Generally, approaches for eye localization can be classified into three categories: template based methods, feature based methods and appearance based methods. In the template based methods [7], a general eye model, based on the eye shape, is designed first.

Oliver et al. [8] proposes a three stage method for robust and precise eye localization. All stages are based on cascaded AdaBoost classifiers [9], and the outputs are interpreted under a probabilistic framework. The first two stages follow a top-down scheme: first a standard Viola-Jones face detector gives the face bounding box, after that the face region is vertically divided in two sections. Each of them is separately scanned with an eye detector with threshold set to a low value in order to collect detected points. The eye detections are sub-sampled according to proximity (by exploiting the face size) and to their probability. This step is necessary to reduce the number of detections to consider. The last stage proceeds in a bottom-up fashion: the detected points are paired in all possible ways and a specifically trained eye-pair classifier identifies the three most probable eye pairs. Finally, the average position of the three pairs gives the eye localization.

Zhi and Xin [10] proposed the generalized projection function (GPF) to detect the eye positions, which gracefully combines Integral Projection Function (IPF) and Variance Projection Function (VPF). Both IPF and VPF can be viewed as special cases of GPF. Another special case of GPF, i.e. the hybrid projection function (HPF), which inherits both the robustness of IPF and the sensitiveness of VPF, is empirically developed. Experiments on three face databases show that all the special cases of GPF are effective in eye detection. Nevertheless, HPF is better than both IPF and VPF, while VPF is better than IPF. Moreover, it is found that IPF is more effective on the occidental face databases than on the oriental face databases, and VPF is more effective on the oriental face databases than on the occidental face database. An analysis of the detections reveals that such a race effect may owe to the shadow caused by the noses and eyeholes of different races of people.

Hsin et al. [11] presented an efficient method for face detection and eye localization using neural network for color segmentation. A self-growing probabilistic decision-based neural network (SPDNN) is used to learn the conditional distribution for each color classes. Pixels of a color image are first classified into facial or non-facial regions, so that pixels in the facial region are followed by eye region segmentation. The class of each pixel is determined by using the conditional distribution of the chrominance components of pixels belonging to each class. However, skin tone detection does not perform equally well on different skin colors and is sensitive to changes in illumination [12].

José Gilvan et al. [13], present a new efficient method for accurate eye localization in color images. This proposed algorithm is based on robust feature filtering and explicit geometric clustering. This combination enhances localization speed and robustness by relying on geometric relationships between pixel clusters instead of other properties extracted from the image. Experiments were conducted with 1532 face images taken from a CCD camera under (real-life) varying illumination, pose and expression conditions. The proposed method presented a localization rate of 94.125% under such circumstances.

## 3. System Overview

This proposed method is a combinatorial approach of fast corner detector and image thresholding using contrast stretching. First the face area has been cropped from color face image. Second this face area has been converted to gray scale image and fast corner detector is applied over this gray scale image. To make this proposed method more prominent the contrast of the respective gray scale image has been stretched (increased) and finally the fast corner detector has been applied over this modified image and accurate eye location is detected. The block diagram of the system has been presented in Fig. 1.

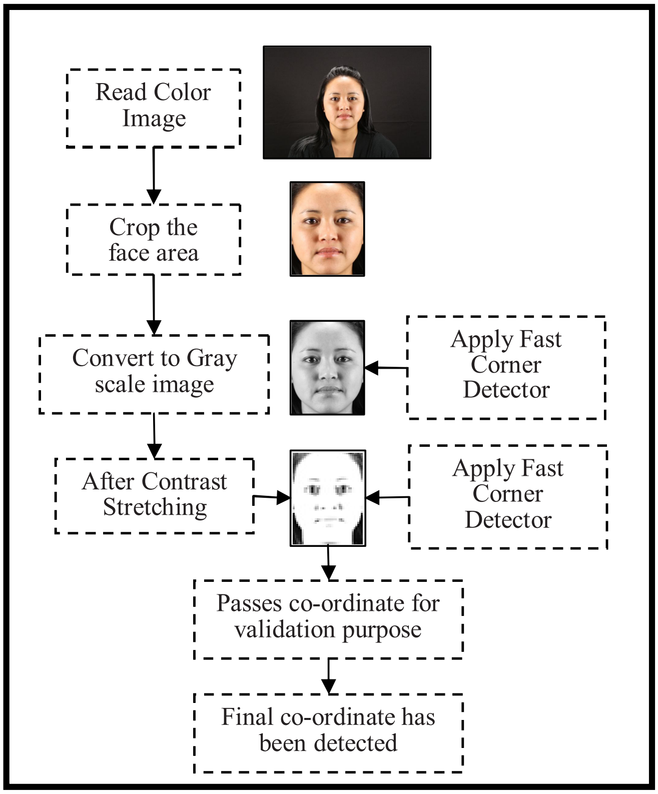


Fig. 1. Flow chart of the proposed method.

### *3.1. Fast Corner Detector*

A Fast Corner Detector is used, for detecting the automatic facial landmark points. Before that, the face area has been cropped, and the color image has been converted into gray scale image. The Fast Corner Detector is applied over the gray scale image for detection of eye location.

A corner can be defined as a point containing two primary edges with distinct directions in a local neighborhood of the point. Corner detectors are commonly used for feature selection because corners correspond to image locations with high information content, which can match between images reliably. These feature point locations are then taken as inputs to high-level computer vision tasks. It is desirable for a corner detector to meet the following criteria:

- **Consistency:** Detected positions should be insensitive to the variation of noise and, more importantly, they should not change when multiple images are acquired of the same scene.
- **Accuracy:** Corners should be detected as close as possible to the correct position.
- **Speed:** Even the best corner detector is insufficient for the real time tasks, if it is not fast enough [14].

### *3.2. Implementation of Fast Corner Detector*

In this work, the 'Univalue Segment Assimilating Nucleus' (USAN) [15] [16] shape is considered for implementing the corner detector. The USAN shape is considered as a random pixel in the image and a circular window around that pixel, which is referred to nucleus. A nucleus is a well defined position in the USAN shape, and can be considered as a corner or an edge or may be a border point of the image. The USAN shape is a small region within the window having pixels with similar brightness to the nucleus [15] as shown in Fig. 2.

The USAN shapes correspond to a point in the uniform area, on the edge and corner. So among these points a Corner Response Function (CRF) has been used for detecting the corner. Corner response function (CRF) is used to distinguish between a comer point Fig. 2(c) and a point that belongs to an edge or a uniform area (a, b) of Fig. 2.

### 3.3. Corner Response Function

The CRF function returns a numerical value for the corner strength based on image intensity in the local neighborhood. An arbitrary line $l$ has been considered which contains the nucleus and the boundary of the circular window at two opposite points $p$ and $p'$. The CRF function is as follows:

$$R_N = \min((f_P - f_N) + (f_{p'} - f_{N'})) \tag{1}$$

where, $N$ is the central location (nucleus) and $f_p$ refers to the image intensity at the point $p$. Three cases can be occurred according to corner response function:

- The center point $N$ is a factor within the uniform area. There is at least one line $l$, so that both $p$ and $p'$ belong to the USAN. In this case, function response is poor.
- The center point is the edge point. There is exactly one line (tangential to the edge), so that $p$ and $p'$ belong to the USAN. In this case, CRF is also poor.
- The center point is a corner point. So in this case, one of the points between $p$ and $p'$ does not function response are high and the corner has been detected belong to the USAN so that the line $l$ and the function response are high and the corner has been detected.

The CRF can be computed by discrete approximation of the circular window having a diameter of 3, 5 and 7 unit pixel. Hence the Eq. (1) can be rewritten as:

$$R_N = \min_{P,P' \in S_N} ((f_P - f_N)^2 + (f_{p'} - f_{N'})^2) \tag{2}$$

where, $N$ is the center point (nucleus), and $p$ and $p'$ are the opposite of $N$ [15] [17] [18]. A sample image with detected eye location using fast corner detector has been shown in Fig. 3.

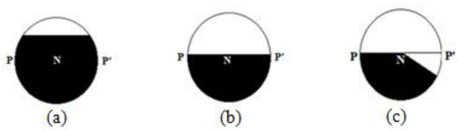


Fig. 2. USAN shapes (a) the center point within the USAN; (b) the center point is an edge; (c) the center point is a corner

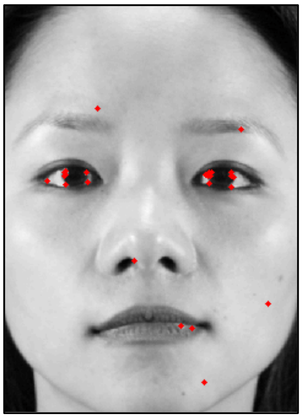

Fig. 3. Output of Eye Detection of gray scale image using Fast Corner Detector

### *3.4. Image Thresholding using Contrast Stretching*

Image thresholding i.e. contrast adjustment of an image is achieved by histogram modeling technique. Image histogram represents a frequency distribution, which represents different classes of intervals of gray scale image and these interval classes are proportional to the corresponding frequencies. A histogram is a function of $m_i$, which counts the class observations those and fall into the disjoint categories. Thus, let $n$ be the total number of classes and $k$ be the total number of frequencies the histogram can be stated as follows:

$$n = \sum_{i=1}^{k} m_i \qquad (3)$$

Contrast stretching has been performed on a certain threshold value. Pixels have been displayed as black, white and gray if the pixel values are below that threshold, above this threshold and in between those two ranges respectively. In Fig. 4 a sample of histograms of gray scale and corresponding contrast stretching image has been shown. This image contrast stretching has been used to reduce the illumination effect and a sample of eye location detection over this modified image using fast corner detector has been shown in Fig. 5.


(a) (b)

Fig. 4. Histograms of (a) Original gray scale image; (b) After Contrast Stretching

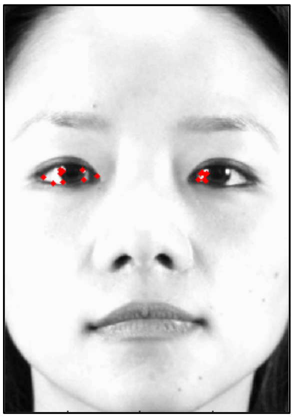

Fig. 5. Output of Eye Detection over Contrast Stretching image using Fast Corner Detector.

## 4. Experiments Results and Discussion

To fully explore the proposed system performance, visual face images have been collected from North-East Indian (NEI) Face database. To check the efficiency the manually selected eye location has been verified against the automatically detected location of eyes. For this purpose 25 sample images have been randomly picked from the database.

### *4.1. North-East Indian (NEI) Face Database*

The North-Eastern face database taken under strictly controlled conditions of lighting, pose etc. and are of different resolutions. The database is being created in the Biometrics Laboratory of Computer Science & Engineering Department of Tripura University, Tripura, India. The images have been captured from five different angles in a single shot using a remote sensor. This dataset covers six universal expression (happiness, surprise, fear, sadness, anger, and disgust), varying with five different poses based on camera positions are +50°, +25°, 0°, -25°, and -50° respectively [19].

### *4.2. Validation Process*

In the validation stage, first the eye locations have been manually detected. Then automatically detected eye locations have been passed for validation stage. To access the viability of the proposed method, 100 face images of NEI face database are used. The performance of the proposed method is evaluated on the basis of the relative error criterion. This procedure was elaborated by O. Jesorsky et. al [8]. The relative error measure based on distances between the expected (automatically detected eye locations) and the estimated (manually) eye position. Let $M_l$ and $M_r$ be the manually extracted left and right eye positions, $A_l$ and $A_r$ be the automatically detected eye positions, $D_l$ and $D_r$ be the euclidian distance between manually and automatically detected eye locations and $D_{lr}$ be the Euclidean distance between $M_l$ and $M_r$ [20]. Then the relative error of eye detection can defined as:

$$R_{err} = \frac{\max(D_l, D_r)}{D_{lr}} \tag{4}$$

If $R_{err} \le 0.10$, the detection is considered to be correct. Therefore, for a face database comprising $N$ images the detection rate is defined as:

$$R = \sum_{i=1}^{N} \frac{i}{N} \times 100, R_{err_{i<0.10}} \quad (5)$$

## 5. Conclusion

In this paper, we have performed an automatic detection of eyes. For this study only frontal face images have been considered and among all the samples eyes have been detected successfully.


## Acknowledgements

The research work has been supported by the grant from Department of Electronics and Information Technology (DeitY), Ministry of Communications and Information Technology (MCIT), New Delhi, Govt. of India, Vide No. 12(2)/2011-ESD, dated 29/03/2011.


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